(NASA-CR-164354) MEASUREMENT OF HO2 AND OTHER TRACE GASES IN THE STRATOSPHERE USING A HIGH RESOLUTION FAR INFRARED SPECTROMETER AT 28 km Semiannual Status Report, 1 Jan. - 15 Jun. 1981 (Smithsonian Astrophysical

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GRANT NSG 5175

Semiannual Status Report No. 8

For the period 1 January 1981 to 15 June 1981

Dr. Wesley A. Traub
Principal Investigator

May 1981

Prepared for

National Aeronautics and Space Administration
Greenbelt, Maryland 20771

Smithsonian Institution
Astrophysical Observatory
Cambridge, MA 02138

The Smithsonian Astrophysical Observatory and the Harvard College Observatory are members of the Center for Astrophysics

The NASA Technical Officer for this grant is Edith I. Reed, Code 963 Laboratory for Planetary Atmospheres, Applications Directorate, Goddard Space Flight Center, Greenbelt, Maryland 20771.

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I. Personnel Working on this Grant During this Reporting Period:

Dr. Wesley A. Traub (Principal Investigator).

Dr. Kelly V. Chance (Co-Investigator).

Dr. Giovanni G. Fazio (Co-Investigator).

Dr. Stephen C. Wofsy (Co-Investigator).

II. Status Summary

During the present reporting period we have been primarily concerned with analysis of data from our December 1980 flight, including efforts in the following areas: (1) computer analysis of the flight spectra to obtain phase corrected, normalized sums of spectra for retrieval of atmospheric profiles, (2) study of atmospheric HF, HCl and H_2O and (3) a limited amount of effort on stratospheric H_2O_2 and HOCl. In addition, we have worked in the following areas which are relevant for this grant, but are nevertheless funded from other sources: (4) laboratory spectroscopy of HOCl (under CMA contract funding) and (5) design study of a new balloon gondola (with Smithsonian internal funding).

(1) An extensive effort has gone into completing the computer analysis necessary for inverting flight data to give stratospheric profiles, taking proper account of the optical depth of lines from trace species, and of interfering lines in the stratospheric spectrum: (a) The majority of the flight data was taken in the low background mode, i.e. with one input to the spectrometer looking at the sky and the other looking at a LN2 temperature blackbody. These spectra required phase correction using the technique outlined in the previous status report (No. 7) to project out the correct part of the complex spectrum. This has

now been completed. The spectra thus obtained are still normalized to the spectrometer response curve (a function of the blackbody spectrum, filters, detector response and some channeling from parallel optical components) and contain a low frequency baseline modulation due to the slight difference in the optics seen by the two inputs to the interferometer. The spectra were grouped according to elevation angle and corrected and normalized by (i) subtracting the baseline ripple and (ii) dividing by a blackbody response function for the spectrometer obtained from the envelope of the spectrum for high background spectra taken during the flight. The result is a number of very high quality coadded emission spectra normalized to a reference blackbody spectrum, summarized in table 1. Examples of these spectra, showing the entire spectral band pass of the instrument are shown in figure 1; (b) An improved atmospheric modelling program for generating stratospheric spectra using the current AFGL line parameter listing is being written. Such a program is vital to our efforts to avoid including interfering lines in our measurement of equivalent widths of lines from stratospheric trace species. Figure 2 is a comparison of a synthetic spectrum with an atmospheric spectrum in spectral regions around several HF and HCl emission lines; (c) Development of an accurate method for retrieving atmospheric profiles from flight data taking atmospheric geometry and optical depth of the lines properly into account, is at a preliminary stage at this time.

(2) Stratospheric HF, HCl and H_2O lines are shown in figure 2, along with a synthetic spectrum from the AFGL line parameter listing. These three molecules are being studied together since

the stratospheric chlorine and fl· rine abundances are very important for evaluation of the effects of chlorofluorocarbons on the ozone layer and the H_2O concentration is correlated to the partitioning of chlorine among the various stratospheric sinks.

HF line broadening parameters appropriate for both the far-infrared rotational lines and the infrared fundamental lines have been derived from the limited HF broadening data in the literature. These are given in table 2. A critical analysis of HF (1-0) stratospheric measurements in the literature is being undertaken in conjunction with our HF analysis.

The results from our present analysis for abundances of HF, HCl and H_2O in the stratosphere above our balloon altitude should be ready to submit for publication within several weeks. The full stratospheric profiles from limb scanning will be obtained as soon as possible.

(3) Measurement of H_2O_2 and HOCl q-branches in stratospheric spectra involves careful removal of interfering spectral lines. Work on these molecules is continuing, along with the program of atmospheric modelling of interfering lines.

(4) Laboratory spectroscopy of HOCl, under CMA contract funding, is in progress. High quality spectra showing the HOCl q-branches under optically thin conditions have been obtained.

Ms. Michel Wilson has been employed as a computer aide under the CMA contract.

(5) A design study for a lightweight balloon platform and telescope specifically designed for stratospheric work is underway, using Smithsonian Institution internal funds. The design under consideration includes the following features: (a) total launch

weight $\leq$ 1000 lb., (b) 9.50 inch f/9 Newtonian telescope, with 12 arcminute field of view and (c) pointing in absolute elevation to 3 arcminutes using feedback from an oil dampened pendulous inclinometer in combination with a rate gyro corrected for earth rotation.

III. Prospects for Future Work

The next reporting period will be spent analyzing flight data to obtain concentrations of stratospheric species and continuing with laboratory spectroscopy under the combination of NASA and CMA funding. We should have the HF, HCl and H_2O results above 29 km submitted for publication early in the reporting period. Complete profiles should be available in several months. Analysis of H_2O_2 and HOCl from our flight data should be substantially complete by that time. B-type transition strengths for the q-branches of HOCl should be available within several months from laboratory spectra. A balloon flight in the fall of 1981 has been effectively ruled out because of refurbishment of the 102 cm balloon-borne telescope.

Table 1

Summary of December 1980 Flight Spectra

Elevation Angle	No. Scans (per detector)	Effective Sampling Height (km)
24.8°	32	33.5
18.0°	16	33.5
8.1°	31	33.3
1.1°	4	31.6
-0.1°	10	31.2
-0.3°	20	28.7
-1.5°	7	26.7
-2.4°	5	23.0

Table 2

Line Broadening Coefficients for HF/air at $225^{o}k$

Transition	γ'/p (cm^{-1} atm^{-1})
(0-0) R0, P1	0.090 ± 0.013
R1, P2	0.090 ± 0.013
R2, P3	0.079 ± 0.011
R3, P4	0.062 ± 0.009
R4, P5	0.056 ± 0.008
R5, P6	0.045 ± 0.009
(1-0) R0, P1	0.108 ± 0.017
R1, P2	0.108 ± 0.017
R2, P3	0.095 ± 0.015
R3, P4	0.074 ± 0.012
R4, P5	0.068 ± 0.011

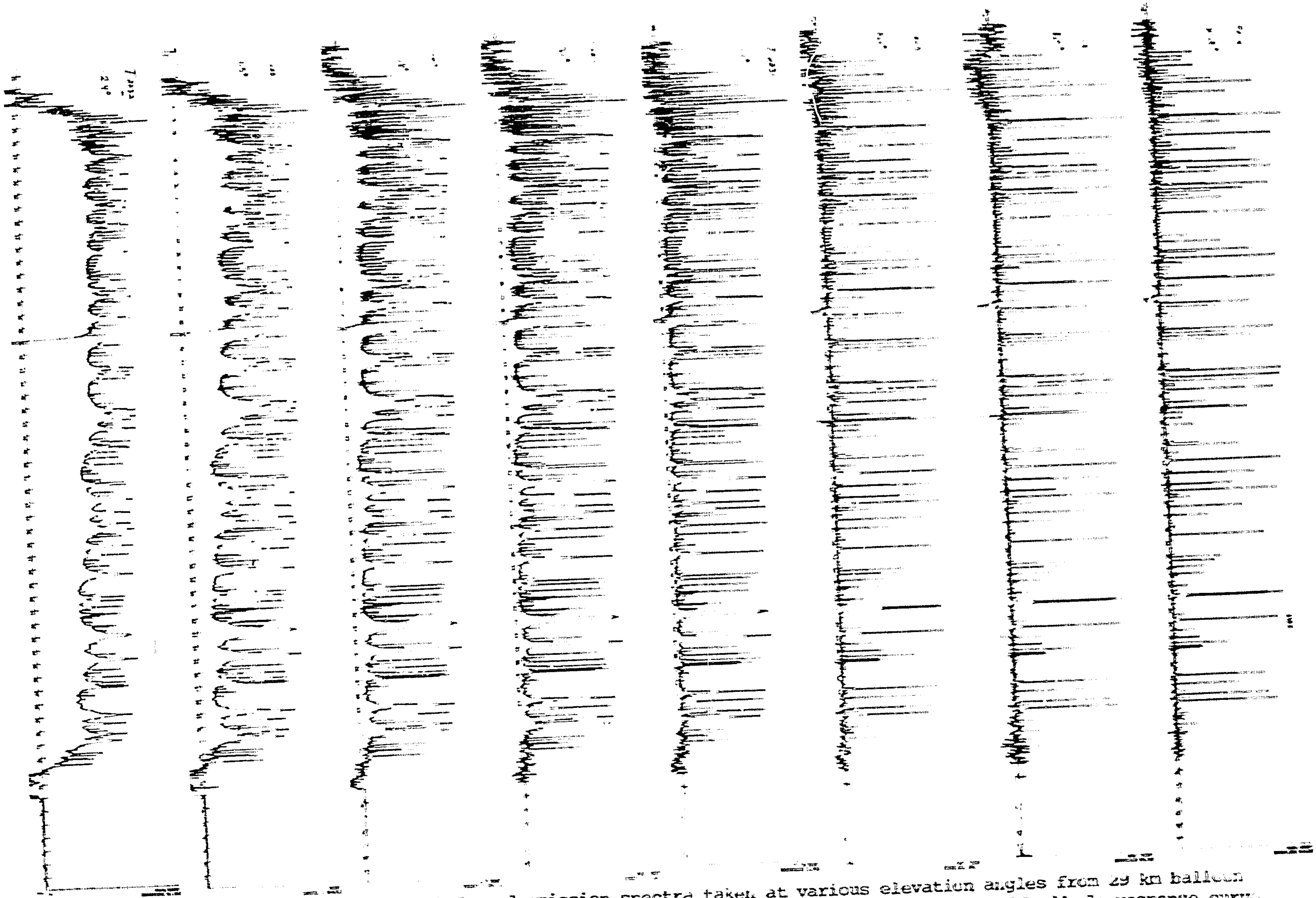

Figure 1 - Stratospheric far-infrared emission spectra taken at various elevation angles from 29 km balloon altitude. The spectra shown here are preliminary in that the normalization to the blackbody response curve is only approximate.

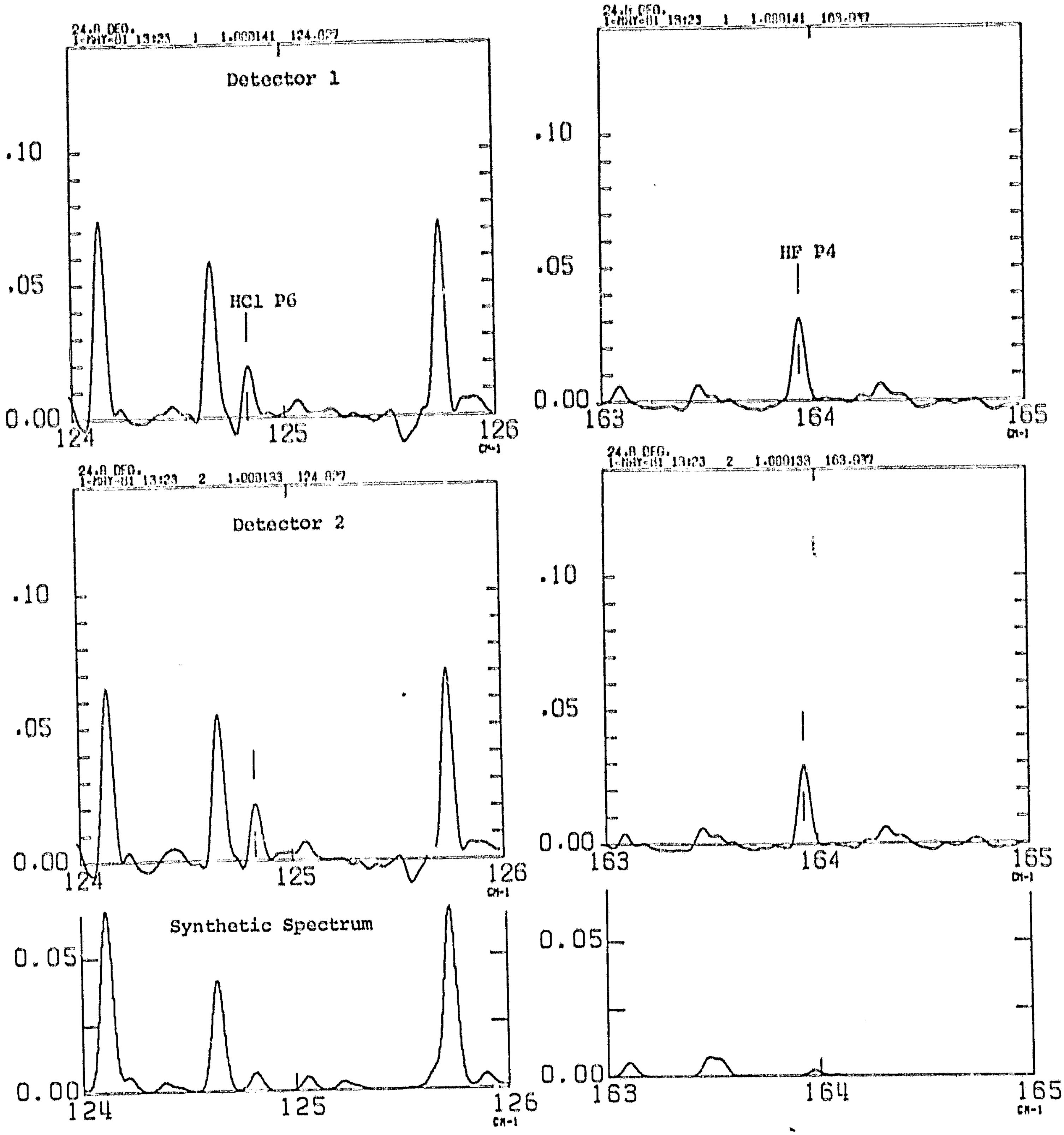

Figure 2 - HF and HCl stratospheric lines at 24.8° elevation compared to a synthetic spectrum using AFGL line parameters.